20.2: New Results on Nano-Textured Surfaces Alignment Layers

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Abstract

In this paper, new results on nano-textured surfaces alignment layers are presented. This NTS is capable of producing any pretilt angle from 0^0 to 90^0. Anchoring strength and temperature stability is studied. Latest results of the two major applications (fast LCDs and bistable LCDs) of these alignment surfaces are also presented.

1. Introduction

A key element to liquid crystal display (LCDs) is the alignment layers which control the liquid crystal orientations at the two boundaries of the LCD panel. The best method of obtaining such alignment layer is by rubbing of a polyimide (PI) layer. Pretilt angles can be produced in the range of 0^0-10^0 and 85^0-90^0 from commercial homogenous PI and homeotropic PI respectively.

Here we demonstrate the application of nano-structured surfaces as the alignment layer. These surfaces comprise micro-domains of commercial horizontal (H) and vertical (V) polyimide. We show that such surfaces can indeed provide variable pretilt angles between 0^0 and 90^0. The measured anchoring energy is very strong and is comparable to ordinary rubbed polyimide. Moreover, these surfaces are robust against high temperatures.

By using these alignment layers, we have achieved large pretilt angles in the range of 40^0 and 55^0 uniformly and reproducibly over a large area. No bias voltage π-cells and bistable bend-splay displays [1] have been successfully made and tested.

2. New Results of Nano-textured surfaces

The basic idea is to use a nano-textured surface as the alignment layer. Such surface consists of domains that are in nano-scale. To realize these alignment surfaces experimentally, we dissolved commercial H and V polyimides in a common solvent allowing them to mix. The resulting solution was then coated onto the glass substrate and cured at 230^0C under vacuum. The solid film was then machine rubbed as in conventional PI. Figure 1 shows a topographic atomic force (AFM) image of the nano-structure surfaces. The dark regions are the V domains while the lighter regions are the H domains.

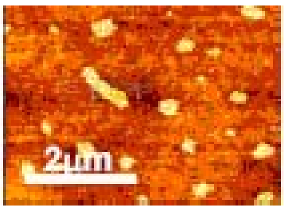

Figure 1: A topographic atomic force (AFM) image of the nano-structure surfaces.

By systematically changing the concentration of vertical polyimide, variable pretilt angles can be obtained. Figure 2 shows a set of 5μm ECB cells. The pretilt angles were measured by using conventional crystal rotation method. Any pretilt angles can be obtained by using nano-textured surfaces.

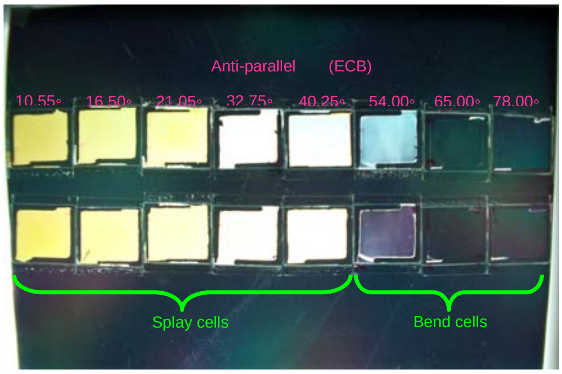

Figure 2: Test cells with different pretilt angles.

For low pretilt angles, the splay cell is more stable with lower elastic deformation energy. The elastic energy increases with increasing pretilt angles as shown in Figure 3. When certain pretilt angles are reached, bend cell is more stable than splay cell.

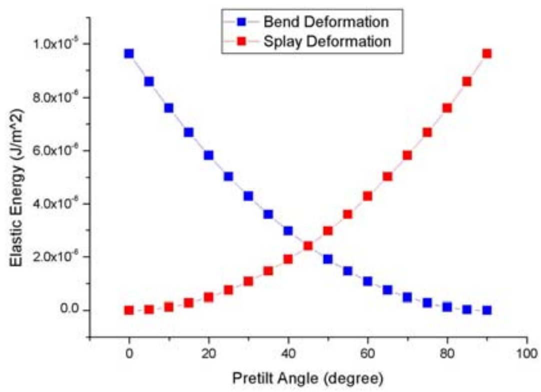

Figure 3: Elastic deformation energy of a splay and a bend cell.

3. Properties of Nano-textured surfaces

3.1 Strong Polar Anchoring Energy

A set of various pretilt angles ECB cells are fabricated to measure the polar anchoring energy. The polar anchoring energy of the LC on these special surfaces has also been measured by the method of RV high voltage technique and differential method [2]. The measured polar anchoring energies are in the range of 1-1.5x10-3 J/cm2 which is the same as ordinary rubbed PI as shown in Figure 4.

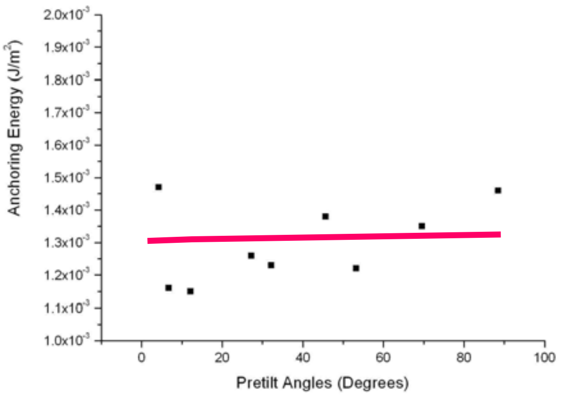

Figure 4: Measured polar anchoring energy of different pretilt angles.

3.2 High Temperature Stability

The high temperature stability of these nano-structured alignment layers was also checked. The pretilt angles remained unchanged after putting into an oven at 180^0C for 24 hours. Table 1 shows the measured pretilt angles before and after baking. In fact, the temperature stability is expected to be good since the components of polyimides are commercially available and demonstrated well for LCD applications.

Table 1. Measured pretilt angles before and after baking

	Before Baking	After Baking
Test Sample 1	32.35^0	32.30^0
Test Sample 2	44.90^0	44.85^0
Test Sample 3	58.65^0	58.65^0

3.3 Wide Operating Temperature

Figure 5 shows the pretilt angles of a 45^0 test cell heating from 10^0C to 80^0C. It can be seen that the pretilt angles remain almost unchanged throughout the test. Therefore, the new alignment layers described here are suitable for commercial LCD applications.

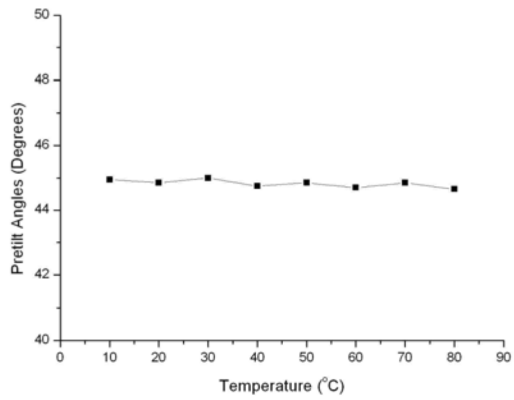

Figure 5: Measured pretilt angles of a 45^0 test cell heating from 10^0C to 80^0C.

4. Applications

The availability of a reliable method of manufacturing large pretilt angles is important for many applications. The most important two are the fabrication of π-cells with no bias voltage and bistable bend-splay LCDs.

4.1 No-Bias Bend π cell

As is well known, π-cells are actually stable in the splay deformation. A critical voltage is needed to transform the splay cell into a bend cell [3]. Figure 6 shows the critical voltage needed to stabilize the bend state for π-cells with various pretilt angles. It shows that when the pretilt angles are above 50^0, no voltage is necessary to hold the bend state. The π-cell can be stable in the bend deformation even without a bias voltage. This is termed the no-bias bend (NBB) cell.

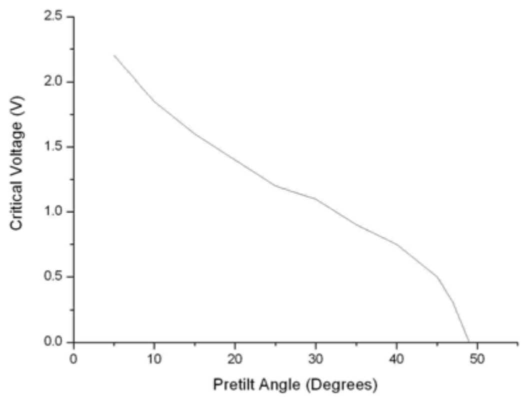

Figure 6: Measured critical voltage needed to stabilize the bend state.

We have made NBB π-cells using this new technique. Figure 7 shows the response time of this π-cell. The plot on the top shows the off time which is less than 1.8ms. The plot on the bottom shows the on time which is less than 80μs. It can be seen that the total response time is faster than 2ms. The average is less than 1ms.

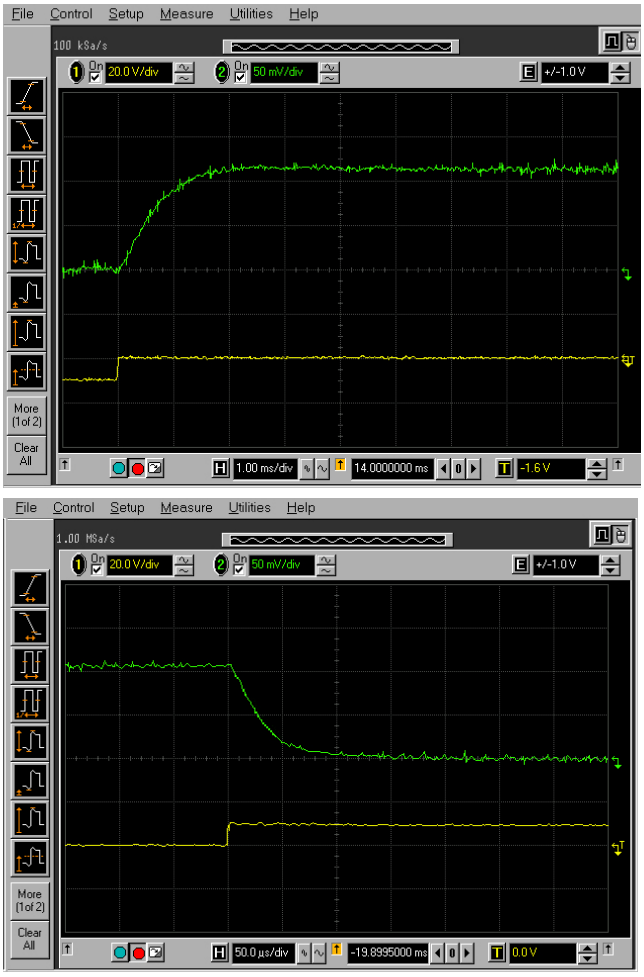

Figure 7: Switching response time of NBB cell. Top: Off time; Bottom: On time.

4.2 Bistable Bend-Splay LCDs

The second important application is bistable displays. Truly bistable bend-splay (BBS) LCD can be made by using these alignment surfaces. These displays are low power consumption, has excellent viewing angles and contrast ratios. The image can be held on the display panel forever without any decay. Figure 8 shows one of the 16x16 BBS LCD fabricated. This alignment technique, together with the dual frequency driving technique, make the bistable bend-splay display a serious contender in the field of e-book and signage applications against other technologies such as BTN and ZBD.

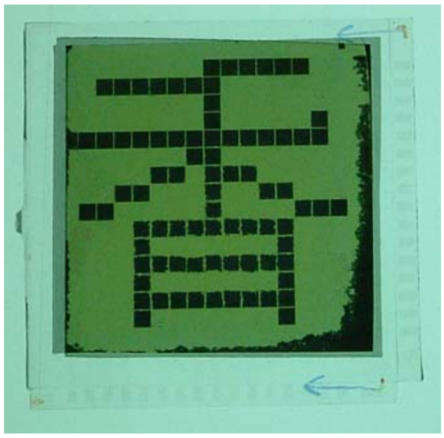

Figure 8: A passive matrix 16x16 bistable bend-splay LCD.

5. Conclusion

A nano-textured alignment layer is introduced which is capable of producing any pretilt angle reliably in a liquid crystal cell. It relies on the formation of nano-structures comprising domains of V and H alignment materials. This method does not involve untested new materials and is compatible with existing manufacturing techniques. This is a new concept in LC alignment and should lead to new applications.

6. Acknowledgements

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7. References

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